Thesis/
Reports
Duffield,
J. W.
c. 1

RECREATION BENEFITS OF INSTREAM FLOW: APPLICATION TO MONTANA'S BIG HOLE AND BITTERROOT RIVERS

by
J.W. Duffield & S.M. Ehlers

Library

Final Report

RECREATION BENEFITS OF INSTREAM FLOW: APPLICATION TO MONTANA'S BIG HOLE AND BITTERROOT RIVERS

John W. Duffield and Susan M. Ehlers
Department of Economics
University of Montana, Missoula

Thomas C. Brown
Rocky Mountain Forest and Range Experiment Station
USDA Forest Service, Fort Collins

January 1991

This document constitutes Final Report B of a study entitled "Economic Value of Recreation and Preservation Benefits of Instream Flow" funded by the USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, through contract 28-K7-428 with the University of Montana.

LIBRARY COPY
ROCKY MTN. FOREST & RANGE
EXPERIMENT STATION

ABSTRACT

An important public policy issue in the Western U.S. is the allocation of water between instream uses including recreation and fisheries and consumptive uses such as irrigation. One basis for identifying appropriate levels of instream flows is maximization of net economic benefits. Since markets do not exist for most instream uses, valuation requires use of nonmarket techniques. This study provides a general framework for estimating the recreational value of instream flows. An application to Montana's Big Hole and Bitterroot Rivers is presented. Based on dichotomous choice contingent valuation, the marginal value of instream flows is in the range of $10 to $20 at low flow levels for these rivers. Precision of the estimates is examined through a simulation approach. At some flow levels, allocative gains may be achieved on the study rivers by reallocating water from consumptive to instream uses.

Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers

INTRODUCTION

The allocation of water among competing uses is an increasingly important public policy issue in the Western U.S. As both consumptive uses and water-based recreation have increased, policies of instream flow reservation have emerged in many states (McKinney and Taylor, 1988, Reiser et al. 1989). Montana's 1975 Water Use Act, for example, formally recognized that instream flow for recreational and other purposes was a beneficial use of water. Instream flow reservation requests to protect fish, wildlife and recreation resources in Montana to date have been based on a model that relates discharge to the wetted perimeter of the stream cross-section (Leathe and Nelson, 1986). As Ward (1987) notes, the use of largely hydrological and biological criteria is typical of streamflow studies.

An alternative basis for identifying appropriate levels of instream flows is to compare the economic values of instream flow to competing consumptive uses such as irrigation or municipal withdrawals. Consumptive uses are typically marketed commodities or inputs to marketed commodities, so their values are relatively well-understood. However, instream uses are generally not marketed, requiring novel approaches to estimation of their economic value.

Streamflow levels can influence recreation benefits through a variety of mechanisms. Flow levels directly influence the quality of whitewater boating experiences (Shelby et al. 1990) as well as stream aesthetics for general shoreline use (Brown and Daniel 1990). Streamflow at any given time affects fishing via influences on the locations, distribution, and behavior of fish and aquatic insects. Over time, streamflows affect fish stock levels and associated angler catch rates (Johnson and Adams, 1988), as well as general recreation and aesthetics via effects on streamside vegetation (Shelby et al. 1990).

The purpose of this paper is to present a general framework relating alternative streamflow levels to economic net benefits (U.S. Water Resources Council, 1983) and to report on an application to several Montana trout streams. A general objective in our research has been to estimate behavioral relationships largely derived from observed behavior and conditions. Accordingly, our model of the effect of streamflow on recreational participation is based on observed use and actual flow conditions. Our model of the relationship of willingness-to-pay and flow conditions is based on responses obtained for experienced environmental conditions. We provide a synthesis and application of methods for interpreting the effect of covariates in contingent valuation models. Measures of the precision of our

estimates are provided through a simulation (Krinsky and Robb, 1986) approach. The allocative implications of our findings are discussed.

BACKGROUND

Previous economic studies of instream uses have measured either the effect of flows on the quality of the experience (Walsh, Ericson, Arosteguy, and Hansen, 1980; Daubert and Young, 1981; Boyle, Welsh, Bishop and Baumgartner, 1988; Johnson and Adams, 1988), or on participation (Narayanan, 1986; Ward, 1987). Both of the latter studies basically used the travel cost method to establish the value of a given recreational trip, but the effect of flows was based on a "contingent behavior" question relating participation to flow. In all of the other studies, respondents were asked to evaluate scenarios of alternative recreational experiences. For example, Johnson and Adams (1988) asked anglers to value increments in catch rates for John Day River steelhead; Daubert and Young (1981) asked anglers, whitewater boaters and shoreline users to value alternative flow scenarios depicted by color photos of several Cache La Poudre River sites; Walsh et al queried users of nine Colorado rivers with both flow and congestion scenarios. All of these studies, with the exception of Johnson and Adams (1988), measure the concurrent relationship of streamflow and recreation benefits. The innovative John Day River study utilized a multiperiod biological model to link the time path of streamflows and the resulting catchable fish stocks.

What is absent from the literature is a general model that can measure the full range of possible influences of streamflow on recreation benefits. Relatedly, the limitation of previous applications is the focus on only one or several of the possible important linkages. Walsh et al (1980) perhaps comes closest to at least modeling both concurrent quality and participation effects of flow, however, participation is not observed or predicted, but a design optimal level based on the congestion-flow relationship. It should be noted that in some applications, the empirical focus on only one aspect of the streamflow-benefit relationship may be entirely appropriate. For example, the excellent Boyle, Welsh, Bishop and Baumgartner (1988) study of whitewater boating in the Grand Canyon of the Colorado, ignored the effect of flows on participation since use is on a permit basis and is essentially fully allocated at all times.

We present a general multiperiod framework for estimating the recreation value of instream flows that includes the direct effect of flows on trip valuation (quality change) and participation. Additionally, the model can incorporate the indirect effects of flows on trip values (for example, congestion effects) as well as multiperiod lagged effects such as the streamflow-angler success relationship.

The specific valuation method used in this study is the dichotomous choice or referendum question format. This is a relatively new approach (Bishop and Heberlein 1979) that appears to overcome some of the bias and participation problems of the bidding game and open-ended format. In order to utilize dichotomous choice, we draw on recent work that examines the relationship between the welfare measure and covariates in these types of models (Cameron 1988 and Patterson and Duffield, 1991). We show that covariate effects can be defined for a variety of welfare measures.

GENERAL FRAMEWORK FOR VALUING INSTREAM FLOWS

The present net worth (PNW) of the recreational benefits of a given river resource can be represented in a discrete time period model (where t can be in annual, seasonal or daily units). Recreational benefits are a multiplicative function of participation and the welfare measure for homogeneous units of recreational use. The latter is typically a compensating variation measure (Hicks 1943) of willingness to pay per day of activity. These elements are in turn a function of a variety of environmental and social factors. The model is given by:

$$PNW(\vec{F}) = \sum_{t=0}^{n} Q_t(F_t, \vec{Z}) \cdot W_t(F_t, Q_t(\cdot), S_t(F_{t-s}), \vec{X}) \cdot (1+B)^{-1} \quad (1)$$

where F is the vector of the F_t daily or seasonal streamflows, B is the discount rate, Q_t is the measure of recreational participation in period t, W_t is a measure of individual net willingness-to-pay in period t, S_t is a measure of recreational quality such as angler success, Z is a vector of site environmental conditions in period t, and X is a vector of socio-economic factors such as income and preferences.

The basic structure of this model derives from Bradford's (1970) aggregate bid function. Because this model is limited to direct recreational use it does not provide a measure of indirect values (such as existence, option or bequest values (Krutilla 1967)) that may be associated with adequate streamflows. Addressing indirect values would require a sample frame based on households rather than onsite users. For an application see Duffield, Ehlers and Allen (1990).

The value of a unit change in flows for any time period t is given by the partial total derivative of PNW with respect to F_t. For example, when t corresponds to the current period:

$$\frac{dPNW}{dF_t} = \frac{\partial Q_t}{\partial F_t} \cdot W_t + Q_t\left(\frac{\partial W_t}{\partial F_t} + \frac{\partial W_t}{\partial Q_t}\frac{\partial Q_t}{\partial F_t}\right) + Q_{t+a}\left(\frac{\partial W_{t+a}}{\partial S_{t+a}} \cdot \frac{\partial S_{t+a}}{\partial F_t}\right) \cdot (1+B)^{-a} \quad (2)$$

The marginal value of a given unit of flow (eg. dollars per acre foot) is the sum of the effect of instream flows on participation, quality of the recreational experience and lagged effects.

In the context of this model, previous applications have examined any one of the three major possible effects. The applications by Narayanan (1986) and Ward (1987) measured the participation effect described by the first term in equation 2, while applications by Walsh, Ericson, Arostequy and Hansen (1980), Daubert and Young (1981), and Boyle et al. (1988) correspond to the concurrent effects of instream flow on the quality of the recreational experience (second term in equation 2). Johnson and Adams' (1988) model is an example of a model examining lagged effects, corresponding to the third term in equation 2. It is possible that only one or two of the three terms may be empirically significant for a given resource. However, it is also possible that all three effects may be important. To the extent that the signs on the partial derivatives are positive in the streamflow range of interest, an implication of this framework is that previous estimates of recreational instream flow values may well be conservative.

The specification here is only intended to illustrate the basic types of linkages. For example, one could easily incorporate a lagged effect on participation into the model (for example, previous success could influence current use levels). Similarly, additional quality factors (lagged or unlagged) could be introduced. The model could also be specified for continuous rather than discrete time. The marginal valuation given by equation (2) is for a change over the time period; one could also compute the present net worth of a change in an annual flow regime or over several time periods or for perpetuity.

EMPIRICAL MODEL

An application of this general framework is presented in the following sections. A single period model that integrates both participation and quality effects of streamflow on recreation was estimated for two Montana trout streams, the Bitterroot and the Big Hole rivers. The estimation of lagged effects, while potentially important, was beyond the scope of our study.

Empirical Setting

Both rivers selected for our empirical application are "blue-ribbon" trout fisheries with the major limiting factor being severe dewatering that can occur during the summer irrigation season.

The Big Hole is one of the premier trout fisheries in North America. It starts near Jackson, Montana in a broad valley bounded by the Bitterroot, Pioneer and Pintler Mountains. It circles around the Pioneers to where it joins the Beaverhead (to form the Jefferson) at Twin Bridges. In the middle section of the river, between Wise River and Melrose, the valley narrows in a canyon. This canyon section is world-renowned for its dry fly fishing for browns and rainbows. Particularly during the salmon fly hatch in mid-June, the river attracts anglers from across the nation.

The Bitterroot is also a good fishery, but reflecting the considerably higher population density of the Bitterroot Valley (compared to the Big Hole) receives the bulk of its use from floaters and general shoreline recreationists. This river flows north from the junction of the East and West Forks south of Darby, Montana to where it joins the Clark Fork in Missoula. While the Big Hole has a well-defined and generally stable stream bed, the Bitterroot is a river on the move, constantly redefining its course through braided and cotton-wood lined channels. The Bitterroot has a major reservoir (Painted Rocks) on its West Fork tributary. In recent years, the Montana Department of Fish, Wildlife and Parks (DFWP) has purchased water from this reservoir to supplement summertime flows and has monitored the effect of flows on the fishery (Spoon 1987). DFWP has developed specific minimum instream flow recommendations for the entire Upper Missouri River Basin, which includes the Big Hole.

Like most Montana streams, the Big Hole and Bitterroot have pronounced seasonal variation, with runoff due to snowmelt peaking in June and low flows for the year in August or September. Both rivers have extensive historical flow records maintained by the U.S. Geological Survey; the mean flow at Melrose on the Big Hole is 1152.8 cubic feet per second (cfs) on a 65 year record. June flows average 4055 cfs and August 479. The historic mean flow on the Bitterroot at Darby is 909.4 cfs (51 years of record), with mean June and August flows of 3197 and 376 cfs respectively.

Valuation Framework

In this application, we estimate a single period version of equation 2, or:

$$\frac{\partial T}{\partial F} = Q(\cdot)\ \frac{\partial W}{\partial F} + W(\cdot)\ \frac{\partial Q}{\partial F} \qquad (3)$$

This model incorporates both quality and participation effects based on actual conditions. In the next section we describe our empirical model for estimating the effect of flow levels on W(·) willingness-to-pay, and then describe our model of participation Q(·).

Dichotomous Choice Contingent Valuation

In dichotomous choice, individuals respond "yes" or "no" as to their willingness to pay a given cash amount for a specified commodity or service. The advantages of this approach, as compared to open-ended or bidding game questions formats, have been discussed elsewhere (Boyle and Bishop (1988) and Bowker and Stoll (1988)). The disadvantage of this approach is that analysis and interpretation are relatively complex, since WTP is inferred rather than observed.

For the case at hand, we examine the value of the recreational experience (the recreation trip) at various experienced flow levels. This contrasts with, for example, Daubert and Young's (1981) approach of facing respondents with each of seven hypothetical instream flow levels varying from 50 to 1150 cfs. Boyle et.al. (1988) demonstrate two specific approaches in a study of white water rafting in the Grand Canyon. The first, which they term "unexperienced scenarios" is very similar to Daubert and Young's approach: respondents are asked to value a specific flow level based on a description of the recreation experience corresponding to that flow. The second basic approach is to include actual flow levels as an explanatory variable in the logistic regression estimate. The latter is similar to the approach taken here, except that Boyle et.al. report welfare estimates conditional on several discrete flow levels rather than estimating continuous marginal values.

We have chosen to value the trip because this is the logical unit of analysis for recreation behavior (McConnell, 1975) and because we feel that the hypothetical situation posed for valuation of the current trip is both simple and relatively easily communicated in an interview setting. This should minimize hypothetical bias.

Our general strategy is to develop a model with instream flow as a covariate and to identify the relationship of flow and valuation analytically. Accordingly, in the discussion of our empirical valuation model that follows, the choice of specification and welfare measure is influenced by whether covariate effects can be derived. This emphasis is somewhat different than in most of the contingent valuation literature where the emphasis is simply on valuation. Because of model complexity, only recently have investigators begun to explore the

influence of covariates on welfare measures in dichotomous choice models (Seller, Stoll and Chavas, 1986; Cameron, 1988). We derive an empirical model for which both derivatives are defined for a variety of welfare measures.

Hanemann (1984) has investigated the theoretical motivation for dichotomous choice models. He provides both a utility difference approach and an alternative derivation based on the relationship of the individual's unobserved true valuation compared to the offered threshold sum (see also Cameron 1988). In the latter, it is assumed that if each individual has a true willingness-to-pay (WTP), then the individual will respond positively to a given bid only if his WTP is greater than the bid. For example, suppose that an individual is confronted with an offered price (t) for access to a given resource or recreational site. The probability of accepting this offer $\pi(t)$, given the individual's true (unobserved) valuation WTP is then:

$$\pi(t) = Pr(WTP > t) = 1 - F(t) \tag{4}$$

where F is a cumulative distribution function of the WTP values in the population. In the logit model $F(\cdot)$ is the c.d.f. of a logistic variate and in the probit model $F(\cdot)$ is the c.d.f. of a normal variate.

The specification of this model can be briefly illustrated for the case where the WTP values are assumed to have a logistic distribution in the population of interest conditional on the value of covariates. A statistical model is developed that relates the probability of a "yes" response to explanatory variables such as the bid amount, preferences, income, and other standard demand shifter type variables. The specific model is:

$$\pi(t;\bar{X}) = [1 + \exp(-\alpha t - \bar{\gamma}'\bar{X})]^{-1} \tag{5}$$

where $\pi(t;\bar{X})$ is the probability that an individual with covariate vector $\bar{X}$ is willing to pay the bid amount t. The parameters to be estimated are α and $\bar{\gamma}'$ (the constant term is included in $\bar{X}$). The equation to be estimated can be derived as:

$$L = \ln[p/(1-p)] = \alpha t + \bar{\gamma}'\bar{X} \tag{6}$$

where L is the "logit" or log of the odds of a "yes" and p are observed response proportions. In application the logit and probit models are so similar that it is difficult to justify one over the other on the basis of goodness of fit. We choose to work with the logistic specification here because the probit model does not lead to closed-form derivatives.

Maximum likelihood estimates of the parameters in equation 6 can be obtained with a conventional logistic regression program. Cameron (1988) has provided an alternative parameterization of this model that emphasizes the threshold motivation and the dependence of individual WTP on covariates. The alternative parameterization requires a general maximum likelihood program. Because the two parameterizations are statistically equivalent (Patterson and Duffield, 1991), we have chosen to use the conventional parameterization here.

Hanemann (1984) has shown that the linear specification in equation 6 is consistent with utility maximization based on his utility difference motivation. However Cameron (1988) argues that from the standpoint of the threshold motivation, any of a variety of WTP distributions are theoretically plausible. This implies that the choice of functional form for $F(\cdot)$ be based on empirical considerations. Many investigators (e.g., Boyle and Bishop (1988) and Bowker and Stoll (1988)) have found that WTP distributions are skewed to the right. In these cases, a better estimate may be obtained with a log-logistic model (replacing t in equation 6 with log t). We apply both forms of the model below.

The responses to our specific valuation questions (described below) provide a Hicksian compensating variation measure (Hicks, 1943) of welfare change for increments of recreational and existence value services. However, since with dichotomous choice contingent valuation we estimate the distribution of WTP values, the question remains as to which parameter of the distribution to use. A variety of welfare measures for dichotomous choice models have been proposed in the literature including a truncated mean (Bishop and Heberlein, 1979), the overall mean and percentiles of the distribution, including the median (Hanemann, 1984, 1989). In all cases the distribution of F is assumed to be continuous and nonnegative. As developed below, we utilize the truncated mean and several different percentiles in this application. The overall mean is defined by:

$$E[WTP] = \int_0^\infty xf(x)\,dx = \int_0^\infty [1 - F(x)]\,dx \qquad (7)$$

where $f(x)$ is the probability density function of the distribution. The p^{th} quantile (100 p^{th} percentile) of the distribution is given by:

$$\eta(p) = F^{-1}(p) \tag{8}$$

For the log-logistic model, the mean is given by:

$$\mu(\bar{x}) = \exp(-\bar{\gamma}'\bar{x}/\alpha)\,\Gamma(1-1/\alpha)\,\Gamma(1-1/\alpha) \tag{9}$$

where $\Gamma(\cdot)$ is the gamma function. We assume that $1/\alpha<1$ so that the mean exists (otherwise E[WTP] is infinite). The p^{th} quantile is given by:

$$\eta_p(\bar{x}) = \exp(-\bar{\gamma}'\bar{x}/\alpha)\,[p/(1-p)]^{1/\alpha} \tag{10}$$

Of course when p = .50 equation 10 provides an estimate of the median. For the case where WTP values are skewed, the median and the mean may differ considerably, as demonstrated in previous studies (e.g. Bowker and Stoll, 1988). As Hanemann (1989) has discussed, choice of the welfare measure is a value judgement in that there is an implicit weighing of whose values are to count. Hanemann has also suggested the 75th percentile as an alternative. We report all three measures: the overall mean, the median and the 75th percentile below.

The partial derivatives of (9) and (10) with respect to a covariate x are:

$$\frac{\partial \mu(\bar{x})}{\partial x_i} = (-\gamma_i/\alpha)\,\mu(\bar{x}) \tag{11}$$

$$\frac{\partial \eta_p(\bar{x})}{\partial x_i} = (-\gamma_i/\alpha)\,\eta_p(\bar{x}) \tag{12}$$

Obviously, these partial derivatives have the same form. The elasticity of either welfare measure with respect to the covariate x_i is equal to $-\gamma_i x_i/\alpha$. This indicates that the

proportional change in either of these measures with respect to a fixed change in x_i is constant (Patterson and Duffield, 1991). This is an interesting result and applies to a broad range of welfare measures including the mean and any percentile of the WTP distribution. It may be noted that the widely used truncated mean welfare measure does not have defined derivatives.

Participation

Another element in our flow valuation model (equation 3) is $Q(F, \tilde{Z})$. $Q(\cdot)$ is use per day for a given recreation site. This is modeled as a second (or higher) order polynomial in the flow variable (F) plus an assumed linear relationship to a vector of other explanatory variables ($\tilde{Z}$) such as a weekend/weekday dummy variable and other environmental conditions, such as weather, that might affect daily use or:

$$Q(F) = B_0 + B_1 F + B_2 F^2 + \sum_{i=3}^{n} B_i Z_i \qquad (13)$$

In contrast with this specification, Narayanan (1986) uses a logistic model to measure participation. The limitation of the logistic specification is that use is not necessarily a continuous positive function of flows but will likely turn negative as flows reach very high levels. A second order or higher polynomial specification (depending on signs of estimated parameters) may permit identification of an optimal flow level in terms of participation. Equation 13 can be estimated using ordinary least squares.

The model described above can be aggregated in two ways. The first is to simply evaluate all functions at the sample means and estimate marginal values for an average day over the season. The effect of changing flow then has the interpretation of a changed flow increment over the season. The average day value is then extrapolated to the season based on the season length. The second approach is to make total value T in equation 1 specific to some time period i. Then equation 1 is evaluated at the variable values that held for that time period. The main variable of interest, flow, can also be set for each time period. Then T for the season is simply:

$$T = \sum_{i} T_i \qquad i = 1....n \qquad (14)$$

By setting flow in period i at a specific level (actual historical, or any hypothetical pattern) the values associated with alternative flow regimes can be evaluated. For example, the incremental benefits associated with maintaining July and August flows at some minimum level can be estimated. For n=1, equation 14 becomes the simple seasonal aggregation at sample means. Depending on the availability of data, time periods could be specified at the day, week or month level. In short, this model can be used to valuing the actual sampled recreation season or be used as a simulation tool to evaluate alternative policy objectives.

Precision of the Estimates

Previous studies of instream flow values have not examined the precision of welfare estimates. However, there have been recent applications to related nonmarket valuation issues that report standard errors for dichotomous choice contingent valuation (Kealy, Dovidio and Rockel, 1988; Duffield and Patterson, 1989; Park, Loomis and Creel, 1989). Because of model complexity, we utilize the simulation approach described by Krinsky and Robb (1986) to estimate standard errors for marginal total instream flow value ($\partial T/\partial F$) as well as all other terms in equation 3. Using IMSL (1989), we drew 1000 repetitions from the asymptotic multivariate normal distributions for the estimated parameters.

APPLICATION TO THE BIG HOLE AND BITTERROOT RIVERS

Data Collection and Survey Design

Onsite surveys were conducted from May 1 to August 26, 1988. On the Big Hole River, the study section was between Wise River and Glen, a 52 mile section of the river which receives about 40% of total Big Hole recreational use. Interviews were collected at nine sites in the upper and middle sections of the Big Hole River, including: Dickey Bridge, Jerry Bridge, Dewey, Divide Bridge, Divide Camping and Fishing Access, Maiden Rock Bridge, Salmonfly Access at Melrose, Brown's Bridge Access and Glen Fishing Access. Onsite interviews on the Bitterroot were taken at four river access sites: Woodside Bridge, Tucker West, Bell Crossing and Stevensville Bridge. These sites encompass 19.5 river miles and account for about 10% of total recreational use on the Bitterroot.

During a typical eight-hour interview day, two hours were spent at each Bitterroot access point, with time of day randomly varied across sites. On the Big Hole, approximately 45 minutes were spent at each access in the course of a day. There were 319 on-site respondents on the Bitterroot and 590 on the Big Hole. Since

the sample frame was similar on both rivers, the larger Big Hole sample reflects the higher use density on this river, particularly in the early season. The onsite surveys gathered information from respondents on a daily level that could be correlated to daily river flows measured at U.S. Geological Survey gauges located at two points along each river. The interviews identified respondent characteristics, river activity share, trip valuation and total visitation. The current trip valuation part of the survey obtained the respondent's estimate of the monetary cost of the trip, and then asked if the respondent "would still have visited" the site if her "personal expenses were [offer price] more." Details of the survey instruments and interview schedule are provided in Duffield, Butkay and Allen (1990).

Site and Respondent Characteristics

Fishing comprised 87% of all use on the Big Hole by the 1988 respondents, compared with only 41% of the Bitterroot respondents (Table 1). Although about 25% of users on both rivers fished from the shore, there was much more float fishing on the Big Hole (50%) than on the Bitterroot (15%). General shoreline activities (picnicking, swimming, etc.) occupied 53% of Bitterroot users but only 7% of Big Hole users.

The importance of angling on the Big Hole and this river's fame is reflected in the type of visitor it attracts. Twenty-nine percent of Big Hole users were from out of state, compared with 16% of Bitterroot users. Mean household income of Big Hole visitors was $41,500 compared to $31,000 on the Bitterroot. Eight percent of Big Hole visitors were on guided trips, compared to only 0.3% on the Bitterroot. The typical trip to the Big Hole entailed more time at the site (25.5 hours compared to 6.8 on the Bitterroot), greater expense per person per trip ($329 verses $133), and was less frequently taken. The average Big Hole respondent had already taken 2.8 trips to the river that year, compared to 8.6 trips for the average Bitterroot respondent. Additionally, 20% of Big Hole respondents considered the river to be crowded, while only 7% of Bitterroot visitors thought that river was crowded.

The summer of 1988 happened to be one of the driest on record, and the Big Hole was particularly hard hit. June flow on the Big Hole averaged only 705 cfs (based on Melrose and Wise River gauge average), or 17% of the historical Melrose mean flow. By August flows averaged 52 cfs, only 10% of the historical mean. The Bitterroot also was below normal, with August average discharge at 216 cfs (Bell Crossing and Darby average), only 57% of the historical average Darby flow of 376 cfs.

Based on individuals sampled per day, use peaked in July on the

Bitterroot and in June on the Big Hole. Nonresident use increased over time on both rivers. On the Bitterroot, only 2% of May users were nonresidents, compared to 29% by August. The absolute change was even more pronounced on the Big Hole, going from 16% nonresident use in May to 63% in August. While visits on the Bitterroot averaged around 7 hours onsite through the summer, on the Big Hole trip length changed from 17 hours onsite in May to 50 hours in August.

For the complete sample, the majority of users on both rivers reported that the flow was adequate for their purposes at the time of interview. Only 19% of all Bitterroot respondents and 31% of Big Hole respondents would have preferred higher flows. However, for July-August, 30% of Bitterroot visitors and 59% of Big Hole visitors would have preferred higher flows.

A formal use survey was not attempted for this study, so we used individuals sampled per day as a proxy. Individuals sampled per day is probably a good index to use on the Bitterroot because it was always possible to sample all individuals observed at the access sites during our selected interview times. On the Big Hole, which was more crowded than the Bitterroot during times of adequate flow levels, it was not always possible to sample all observed individuals. Because this sampling procedure underestimates use at higher flow levels, the participation effect measured by the estimate of equation 13 for the Big Hole is conservative.

Estimation Procedure

Models were estimated for current trip valuation (equation 6) and recreation participation (equation 13). For the former, we examined a large subset of the theoretically plausible independent variable combinations using the maximum likelihood step-wise logistic regression procedure in BMDP (1988). The models reported here were selected on the basis of chi-square goodness of fit statistics and the number and significance level of covariates (based on a t-test). Ordinary least squares regression results reported here for the relationship of participation to flow levels were computed with the SAS (1988) stepwise regression procedure. Models reported are based on the step with the last variable included having an estimated coefficient significant at the 90 percent level, based on a t-test.

Current Trip Valuation

Alternative functional forms (linear in bid or log transformation for this variable) for bivariate logistic models for both study rivers are compared in Table 2. Based on the Pearson and Hosmer-Lemeshow (Hosmer and Lemeshow, 1988) chi-square goodness of fit statistics, the logged model provides a better fit to the data

and is accordingly used in the remainder of this analysis.

Multivariate logistic model estimates of equation 6 for the Bitterroot river are reported in Table 4 for the complete sample and for the shoreline activity group and fish/float activity group subsamples. (Variables are defined in Table 3). In all equations the bid variable is negatively correlated with odds of a yes response and is highly significant. Income and trip length also have the theoretically expected sign and in most equations are highly significant. River discharge (cubic feet per second flow on a daily basis) is positively and significantly correlated to the log of the odds of a positive response; this indicates that trips taken at higher flow levels are more valuable, other things equal. The Hosmer-Lemeshow chi-square statistic indicates that the models provide a good fit to the data.

For the Big Hole model estimate, estimated coefficients also have the expected signs and are highly significant for most variables and subsamples (Table 5). The chi-square statistics indicate that the estimated models provide a good fit to the data. On the Big Hole, place of residence was a highly significant covariate; Montana residents have significantly lower current trip values compared to nonresidents. Three specific models are reported: a model for the complete sample and models for float anglers and bank anglers. The activity split on both rivers was chosen to approximately divide the sample in half.

A surprising result on the Big Hole is that discharge was not significantly correlated to the dependent variable. This finding may be due to the dramatic change in sample composition over the course of the summer on the Big Hole. As noted previously, nonresident use increased from 16 percent to 63 percent from May to August. By August, the only recreationists continuing to use the river were likely to be those least sensitive to instream flows. The model probably can not be extrapolated to the entire population of users, because flow-sensitive users likely went elsewhere during low flow periods. These findings indicate that an "unexperienced scenario" approach may have been preferable for the Big Hole since it would permit obtaining flow valuation responses at a variety of flow levels from all respondents. An interactive variable was defined for the Big Hole to test if higher flows resulted in higher trip values for at least the subsample that stated a preference for higher flows. That variable took the value of observed river gauge height if the respondent reported preferring higher flows and zero if the respondent preferred current or lower flows. In a complete sample logistic model similar to that reported in Table 5, the interactive variable and it square each had the expected signs and were significantly correlated to the probability of a yes response. While informative, this equation is difficult to use for total flow valuation purposes.

Variables designed to measure congestion were included in preliminary estimates. The estimated parameters on these variables were of the right sign, but not significantly different from zero. This contrasts with Walsh, Ericson, Arosteguy and Hansen (1980), who found that congestion had a significant effect on recreational trip valuation for a set of Colorado rivers. However, it appears that on average the Colorado rivers are much more crowded than the Montana study sites. The Colorado sites averages approximately 12 users/mile-day over the sample season, compared to about 2 users/mile-day on the Big Hole and Bitterroot.

Estimated Model of Recreation Use

The estimated use equation for the Bitterroot has expected signs for discharge, weekends, and strong winds and all variables are highly significant (Table 6). In addition, discharge squared and cubed are significant at the 99 percent level. This polynomial fit to the discharge terms indicates that use is initially positively related to discharge, peaks at some optimal flow level (about 1100 cfs for this model) and then declines. This is consistent with the general expectation that use is low at very low flows and at flood levels and is maximized at moderate flows. The equation for the Big Hole shows significant correlations with expected signs for discharge, discharge squared, and dummy variables for cold temperatures and times when the salmon fly hatch is on. Other things equal, when salmon flies were present, use doubled.

Recreation Values of Instream Flows

Estimated net economic benefits for recreational trips to the Big Hole and Bitterroot Rivers are presented in Table 7. Values for three specific welfare measures are provided: the median, 75th percentile, and the overall means. For the Bitterroot, all measures indicate that anglers and floaters on average value trips at three to four times as much as shoreline users. On the Big Hole, float anglers have somewhat higher values on average than bank anglers. The overall mean is much higher than either of the percentile measures; for the Big Hole bank angler sample, the overall mean is undefined (infinite).

Standard errors were computed for the two percentile measures using the procedures of Krinsky and Robb (1986). Based on 1000 repetitions, standard errors for the Big Hole welfare measures are 12 to 14 percent of the estimate, indicating 95 percent confidence intervals that are around plus or minus 25 percent of the estimate. For the Bitterroot, precision of the estimates is somewhat lower, with a coefficients of variation being almost twice as large at 23 to 26 percent of the estimate. This is not surprising given the relative sample sizes (230 and 503 for the

Bitterroot and Big Hole respectively). In fact, the relative standard errors for the two sites imply that standard errors are approximately proportional to the inverse of the square root to the sample size. The latter is a result that has been shown analytically for a related nonparametric dichotomous choice model (Duffield and Patterson, 1991); it is possible that this relationship may also hold for these welfare measures though it is difficult to show this analytically. (The proportionality relationship here is approximate also because other factors affect the standard error including shape of the distribution and distribution of the total sample among bid levels.)

Using the estimated parameters from equations 6 and 13, marginal recreational values for instream flows as in equation 3 were computed for both study sites. Table 8 provides a listing of values per acre-foot at various discharge levels ranging from 100 to 2000 cfs. Results are presented for the 75th percentile welfare measure for the respective complete samples; estimates based on the median would vary in direct proportion to the values of these two percentile measures as reported in Table 7. It may be noted that since recreational trip valuation is in terms of trips but use is per day, it was necessary to compute value per day using observed average days per trip (1.453 and 2.28 for the Bitterroot and Big Hole respectively).

Total marginal values on the Bitterroot range from $13 per acre foot at 100 cfs to zero value at 1600 cfs. The effect of flows on quality of the experience (willingness to pay per day) accounts for about two-thirds of the marginal value while the effect of flows on participation is less important. On the Big Hole, marginal values based on observed changes in participation with flow range from $18 per acre-foot at 100 cfs to zero at just under 1000 cfs. Precision of the estimates was again derived using the Krinsky and Robb (1986) procedure. In this case we drew simultaneously from the two multivariate normal distributions of parameter estimates from our two underlying models: the maximum likelihood logistic model of trip valuation and the OLS model of daily use. At lower flow levels, the 95 percent confidence intervals are from plus or minus 50 to 80 percent of the estimates.

Implications of Incomplete Models

The estimated marginal values presented above for the Bitterroot River can be compared with those from a simplified model where only quality of the experience varies with flow levels, while participation is held constant at average use levels (Table 9). This would correspond to the model used by Daubert and Young (1981). When participation is held constant at average levels, the value change associated with the quality effect is overstated at low flow levels and high flows and of course is similar at

average flows. Compared to total marginal value, modeling just the quality effect with constant use levels understates total marginal value at all discharge levels except 100 cfs for our models.

A related simplified model, similar to that used by Narayanan (1986), is one where value per day is held constant across flow levels, but participation varies. In this case (Table 9), marginal values for the participation effect are also overstated at low flows and converge to this study's estimates at flow levels where average willingness to pay occur. This type of simplified model understates total marginal values at all flow levels for our case.

In general, it appears that both of these simplified models will tend to understate total marginal values. However, depending on the sensitivity of either use or daily value to flows, it is possible that marginal values could also be overstated at some flow levels.

ALLOCATIVE IMPLICATIONS

Irrigation withdrawals are the primary diversionary use of surface water in the Montana, accounting for 96 percent of all consumptive uses (Gibbons, 1986). Irrigation is also the primary consumptive use in the Big Hole and Bitterroot valleys. Accordingly, it is of interest to compare the instream flow values computed here to the values of irrigation water.

Irrigation water values are most logically based on derived factor demand equations. Where the production relationship is known, water values are simply crop price times the marginal physical product. Accordingly, irrigation water values vary dramatically across crop and region. An alternative is to use farm or enterprise budget analysis. In all cases, one needs to be careful to distinguish on-site values and values at the point of diversion. For example, a review by Sammis (1981) of seven crop-water production function studies for alfalfa results in a constant marginal product of .159 tons of alfalfa per inch of water utilized by the plant. Based on average 1986-1988 alfalfa prices for Montana, this implies a marginal value of $124 per acre-foot. However, the most common type of irrigation application in Montana is flood irrigation with 50 percent efficiency and conveyance by unlined ditches averaging 25 percent efficiency. Accordingly, for every acre-foot utilized by the plant, 8 acre-feet must be diverted. It follows that the value per acre foot diverted for alfalfa may be as low as $15.50. On the other hand, with conveyance efficiencies of 50 percent and the application efficiency associated with handline or sidewheel sprinklers (65 percent), values could be as high as $48.

For both the Big Hole and Bitterroot, alfalfa hay is the most valuable widespread irrigated crop. Crops such as other hays may have values that are more on the range of $2 to $15 per acre-foot compared to alfalfa at $15 to $48.

Recall that the direct recreation instream flow values for the Bitterroot and Big Hole study sections range from as high as $13 to $14 dollars at very low flows to zero value at optimal flow levels. A simple comparison of these values to irrigation water values indicates that for some crops and some flow levels, there may be allocative gains to maintaining instream flows. However, in order to do a correct evaluation of a given withdrawal, one would need to be able to characterize the hydrology of the given river basin both with and without the diversion and to identify the potential benefits associated with all instream uses. This is beyond the scope of this study. However, a simple and fairly realistic example can be briefly described for the Bitterroot. To begin, it is necessary to emphasize several key points in any such comparison.

First, it is overly simplistic in most cases to compare the value of an acre foot of diverted irrigated water to an acre foot of instream flows. In most cases, only some share of the irrigated water is consumed; some of the water diverted will re-enter the river as return flows at a point below the diversion. Accordingly, the instream flow loss is for an acre foot only for some distance downstream; thereafter, only some share of an acre foot is lost depending on return flows. Withdrawals can also alter the timing of return flows. Irrigation diversion in spring in the Bitterroot recharge aquifers that feed the mainstem river latter in the summer when the river is low.

Secondly, instream uses are additive both spatially and across uses. Across uses, one would of course want to add hydroelectric and option and existence values to the direct recreation values of instream flows. Spatially, hydroelectric values are additive at each facility downstream from the diversion. For example, Gibbons (1986) reports a cumulative 1,024.86 kilowatt hours per acre-foot for the mainstem Columbia. In 1980 dollars and for the difference in average steam and hydroelectric production costs of 17 mills, this is a value of $17.42 per acre-foot for tributaries in the headwaters of the Columbia, such as the Bitterroot river. These values are undoubtedly very conservative based on current energy prices. They are additionally conservative in this example for excluding the mainstem dams on the Clarks Fork of the Columbia (Thompson Falls, Noxon and Cabinet Gorge). Downstream river recreation segments should also be treated like additive facilities, paralleling the hydroelectric use. To correctly estimate downstream values, one would need to know return flows and also correct for any evaporative losses.

Suppose for the sake of example that a given diversion is at the

start of our Bitterroot River study section and that return flows in the amount of 50 percent of the diversion enter below the study section. As noted, the value of the acre-foot diverted from recreational use in the study section may be as high as $13. This value alone is roughly equivalent to the low efficiency alfalfa hay value and higher than the value of other hays at most plausible irrigation system efficiencies. Adding across river segments, it might be crudely estimated that the value of instream flows in all river segments downstream from our study section (which would include the Clark Fork below Missoula) is equivalent to the value for the entire Bitterroot. The latter value, assuming the study section (which is only 11 percent of the river length) is typical, is as high as $114 at low flows. For one-half an acre-foot (after return flows), this is $57. Additionally one-half an acre foot (ignoring evaporative losses) would contribute at least (.5 times $17.42) $8.71 in downstream hydroelectric benefits. For this simple example, the value of instream flows could be as high as $79 per acre foot for flows around 100 cfs and as low as $9 at 1700 cfs and above. These estimates may still be conservative for excluding option and existence values associated with fisheries and riparian communities on both the Bitterroot and Columbia River.

To summarize, the range of crudely estimated instream flow values (including downriver hydroelectric and recreation facilities) for the Bitterroot is $9 to $79 per acre-foot. Recalling the estimated range of irrigation water values at $2 to $48, it appears that many irrigation diversions, particularly at typical summertime flow levels would not be cost-beneficial. A hydrological model of the river basin and estimates of downstream recreation values would be needed to refine these estimates. A similar example could, of course, also be constructed for the Big Hole.

It is interesting to note that the instream values estimated here are in the range of typical transactions prices for instream flows. Ten instream flow transactions reported in Water Market Update between 1988 and 1989 were between $1 and $7, two were in the $15 to $25 range and another was $50. One of these transactions was a purchase by Montana Department of Fish, Wildlife and Parks of 10,000 acre-feet annually at $2.00 per acre-foot for release from Painted Rocks Reservoir in the Bitterroot headwaters. Given that these releases are during low summer flow conditions, the purchase of these releases appear to be justified by the value generated in the study section alone.

CONCLUSIONS

This paper introduces a general framework for estimating the recreational value of instream flows. The theoretical model incorporates the influence of instream flow levels on both the quality of the recreational experience and on the levels of

participation. The model can be used to value a changed increment to flow over a season or alternative flow regimes. Methods for interpreting covariate effects in dichotomous choice contingent valuation are presented. Procedures for estimating standard errors for welfare estimates and the marginal value of water are demonstrated.

The recreational value model is demonstrated in an application to the Big Hole and Bitterroot Rivers in Montana. Valuation is based on experienced flow levels using a dichotomous choice current trip valuation model, while use is actual observed. A broad range of flows was experienced during the May to August sample season, as the summer of 1988 happened to be one of the driest on record. Valuation varied by user groups with anglers having values that were more than double those for general shoreline recreationists on the Bitterroot. Float anglers had somewhat higher values than bank anglers on the Big Hole. Precision of the estimates is sensitive to sample size, with approximately 500 observations necessary to achieve 95 percent confidence intervals that are plus or minus 25 percent of the median or other percentile welfare measures.

Marginal values per acre foot were found to be in the $10 to $20 range at low flow levels. These estimates were less precise than the estimated value of a recreational trip because of the additional variability introduced by the model of recreational use. This instream flow valuation framework provides a convenient structure for comparing results of previous instream flow research. The Bitterroot model was used to compare instream flow values using the full model specification as well as incomplete models where either participation or quality of the experience are assumed invariant with river discharge. In general, the incomplete models result in underestimates of total marginal values of instream flows at most discharge levels.

Estimated instream flow values on the Bitterroot (including the benefits of downstream hydroelectric generation) were compared to consumptive withdrawals for irrigation. This study indicates that at some flow levels, allocative gains may be achieved by reallocating water from consumptive to instream uses.

Acknowledgements. This study was funded in part by grant #28-K7-428 from the USDA Forest Service Rocky Mountain Forest and Range Experiment Station in Fort Collins. We are indebted to Stewart Allen and John Loomis for their help with survey design. Liter Spence and Fred Nelson also assisted us during the survey design. Chris Neher patiently and efficiently undertook much of the computational work reported here. David Patterson provided critical guidance on statistical procedures. We are indebted to Mel While of the U.S. Geological Survey for his courteous help in obtaining daily discharge readings for the study rivers. Bob McFarland provided us with detailed angler use estimates.

References

Bishop, R.C. and Heberlein, T.A. (1979). Measuring Values of Extra Market Goods: Are Indirect Measures Biased? American Journal of Agricultural Economics. 61: 926-30.

BMDP, Inc. 1988. BMDP Statistical Software. Los Angeles, CA.

Boyle, K.J., and R.C. Bishop (1988). Welfare Measurements Using Contingent Valuation: A Comparison of Techniques. American Journal of Agricultural Economics. 70: 21-27.

Boyle, K.J., M.P. Welsh, R.C. Bishop and R.M. Baumgartner (1988). Analyzing the Effects of Glen Canyon Dam Releases on Colorado River Recreation Using Scenarios of Unexperienced Flow Conditions, in J. Loomis (ed) Benefits and Costs in Natural Resources Planning. Western Regional Agricultural Experiment Stations.

Bowker, J.M., and J.R. Stoll (1988). Use of Dichotomous Choice Methods to Value the Whooping Crane Resource. American Journal of Agricultural Economics. 70: 372-381.

Bradford, D.F. (1970). Benefit-Cost Analysis and Demand Curves for Public Goods. Kyklos. 23: 775-791.

Brown T.C., and T.C. Daniels (1990). Landscape Aesthetics of Riparian Environments: Relationship of Flow Quantity to Scenic Quality Along a Wild and Scenic River. Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Cameron, T.A. (1988). A New Paradigm for Valuing Non-Market Goods Using Referendum Data: Maximum Likelihood Estimation by Censored Logistic Regression. Journal of Environmental Economics and Management. 15: 355-379.

Cameron, T.A. and M.D. James (1987). Efficient Estimation Methods for Use with "Close-ended" Contingent Valuation Survey Data. Review of Economics and Statistics, 69: 269-276.

Cummings, R.G., Brookshire, D.S. and Schulze, W.D. (1986). Valuing Environmental Goods. Totowa, NJ: Rowman and Allanheld.

Daubert, J.T. and R.A. Young (1981). Recreational Demands for Maintaining Instream Flows: A Contingent Valuation Approach. American Journal of Agricultural Economics. 63(4): 666-675.

Duffield, J.W., Butkay, S., and S. Allen (1990). Economic Value of Recreation and Preservation Benefits of Instream Flow. USDA Rocky Mountain Forest and Range Experiment Station, Fort Collins.

Duffield, J.W. and D.A. Patterson (1989). Implications of a Discrete Probability Model for the Design and Interpretation of

Logistic Contingent Valuation, in Benefits and Costs Natural Resources Planning. Western Regional Agricultural Experiment Stations.

Duffield, J.W. and D.A. Patterson (1991). Inference and Optimal Design for a Welfare Measure in Dichotomous Choice Contingent Valuation. Land Economics 67(2): forthcoming.

Gibbons, D.C. (1986). The Economic Value of Water. Resources for the Future. Washington, D.C..

Hanemann, W.M. (1984). Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses. American Journal of Agricultural Economics. 66:332-341.

Hanemann, W.M. (1989). Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses: Reply. American Journal of Agricultural Economics. 70:1057-1061.

Hosmer, D.W. and S. Lemeshow (1980). Goodness of Fit Tests for the Multiple Logistic Regression Model. Commun. Statis. 10:1043-1069.

IMSL, Inc. (1989). IMSL SFUN/LIBRARY, Version 2.1. Houston.

Johansson, P.O., B. Kristrom, and K.G. Maler (1989). Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Comment. American Journal of Agricultural Economics. 70: 1054-56.

Johnson, N.S., and R.M. Adams (1988). Benefits of Increased Streamflow: The Case of the John Day River Steelhead Fishery. Water Resources Research. 24(11):1839-1846.

Kealy, M.J., J.F. Dovidio, and M.L. Rockel (1988). Accuracy in Valuation is a Matter of Degree. Land Economics. 64:158-170.

Krinsky, I. and A.L. Robb (1986). On Approximating Statistical Properties of Elasticities. Review of Economics and Statistics. 68: 715-719.

Krutilla, J. (1967). Conservation Reconsidered. American Economic Review. 57(4):77-86.

Lathe, and Nelson (1986).

McConnell, K.E. (1975). Some Problems in Estimating the Demand for Outdoor Recreation. American Journal of Agricultural Economics 57:330-334.

McKinney, M.J., and J.G. Taylor (1988). Western State Instream Flow Programs: a Comparative Assessment. Instream Flow

Information Paper No. 18. U.S. Fish Wildl. Serv. Biol. Rep. 89(2). 78pp.

Narayanan, R. (1986). Evaluation of Recreational Benefits of Instream Flows. Journal of Leisure Research. 18(2): 116-128.

Park, T., J. Loomis and M. Creel (1989). Confidence Intervals for Evaluating Benefits Estimates from Dichotomous Choice Contingent Valuation Surveys. Manuscript, Department of Agricultural Economics, University of Nebraska.

Patterson, D., and J.W. Duffield (1991). Cameron's Censored Logistic Regression Model: Comment and Extension. Journal of Environmental Economics and Management. (forthcoming).

Reiser, D.W., T.A. Wesche, and C. Estes (1989). Status of Instream Flow Legislation and Practices in North America. Fisheries. 14(2):22-29.

Sammis, T.W. (1981). Yield of Alfalfa and Cotton as Influenced by Irrigation. Agronomy Journal. 73:323-329.

SAS Institute, Inc. (1988). SAS/STAT Users Guide. Release 6.04 Edition. Cary, NC.

Seller, C., J.P. Chavas, and J.R. Stoll (1986). Specification of the Logit Model: The Case of Valuation of Nonmarket Goods. Journal of Environmental Economics and Management. 13:382-390.

Shelby, B., ~~et al. (1990)~~, T.C. Brown, and J. Taylor. ~~Inst~~ (1990). Instream Flows and Recreation. Rocky Mountain Forest and Range Experiment Station.

U.S. Water Resources Council (1983). Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. Washington, D.C.: U.S. Government Printing Office.

Walsh, R., R. Ericson, D. Arosteguy and M. Hansen (1980). An Empirical Application of a Model for Estimating the Recreation Value of Instream Flow. Fort Collins: Colorado Water Resources Research Institute.

Ward, F.A. (1987). Economics of Water Allocation to Instream Uses in a Fully Appropriated River Basin: Evidence From a New Mexico Wild River. Water Resources Research. 23(3): 381-392.

Table 1. Activity Shares by River (Percent of Total Sample).

Activity	Bitterroot	Big Hole
General Shoreline (Picnic, swim)	53.0	7.2
Float	6.4	5.9*
Fish		
Shore fish	24.6	23.6
Fish and camp	1.1	13.6
Boat and fish	14.8	35.3
Fish, float and camp	0.0	14.3
Subtotal Fish	40.5	86.8

* Includes 0.6% float and camp

Table 2. Comparison of Linear and Logged Specification of Bid Variable in Logistic Dichotomous Choice Contingent Valuation Model of Current Trip.

	Estimated Parameters					
	Big Hole		Bitterroot			
Variable/			Shoreline		Fish/Float	
Statistic	Linear	Logged	Linear	Logged	Linear	Logged
Intercept	1.295	5.344	.8708	3.395	.8315	3.923
(t stat.)	(9.31)	(10.97)	(3.69)	(5.80)	(3.45)	(5.68)
BIDT	-.00373	--	-.00747	--	-.00349	--
(t stat.)	(-9.82)		(-4.73)		(-4.15)	
Ln(BIDT)	--	-1.074	--	-.9263	--	-.9179
(t stat.)		(12.10)		(-6.63)		(-6.39)
Chi Square Goodness of Fit Likelihood Ratio						
Chi Square	123.95	26.71	60.21	29.87	77.50	32.95
D.F.	25	25	26	26	28	28
P	.0000	.3705	.0002	.2729	.0000	.2374

Table 3. Variable Definitions for Estimated Models.

Variable	Definition
P	proportion responding yes to given bid amount
BIDT	dollar bid offer for current trip
INCOME	household income in dollars
TRIPTM	hours on site for this trip
DSCHRG	daily average flow in CFS on study sections based on USGS gauges at Wise River and Melrose (Big Hole) and Darby and Bells Crossing (Bitterroot)
AGE	age of respondent
RES	dummy variable with 1 = Montana Resident, 0 if nonresident
NSAMPLE	number of users sampled per day
WKEND	dummy variable for weekend
DUMSTR	dummy variable for strong winds
DUMCOLD	dummy variable for cold temperature
SALDATE	dummy variable for day when greater than 20% of anglers reported fishing the salmon fly hatch

Table 4. Logistic Dichotomous Choice Model for Valuation of Current Trip: Bitterroot River*.

	Estimated Parameters		
Variable/Statistic	ALL	SHORELINE	FISH/FLOAT
Intercept	-9.950	-15.13	-5.861
(t stat.)	(-3.33)	(-3.11)	(-1.40)
ln BIDT	-1.205	-1.227	-1.118
(t stat.)	(20.78)	(5.09)	(5.59)
ln INCOME	1.052	1.537	.5905
(t stat.)	(3.81)	(3.47)	(1.66)
ln TRIPTM	.642	--	.7897
(t stat.)	(3.43)		(2.34)
ln DSCHRG	.506	.6755	.4897
(t stat.)	(2.75)	(2.32)	(1.79)
Sample Size	231	116	115
Chi Square**			
Hosmer-Lemeshow	8.043	4.482	9.537
P	.429	.811	.299
Sample Means:			
INCOME	31740.1	28678.9	34796.7
TRIPTM	7.005	--	10.135
DSCHRG	1451.9	1044.3	1875.3

* dependent variable: L=ln(P/(1-P))
** degrees of freedom for Hosmer-Lemeshow is 8

Table 5. Logistic Dichotomous Choice Model for Valuation of Current Trip: Big Hole River*.

	Estimated Parameters		
Variable/Statistic	ALL	FLOAT ANGLER	BANK ANGLER
Intercept	-2.448	-9.717	5.963
(t stat.)	(-.938)	(-2.63)	(8.45)
ln BIDT	-1.245	-1.463	-.9821
(t stat.)	(-11.22)	(-7.35)	(-8.54)
ln INCOME	.3365	1.442	--
(t stat.)	(1.69)	(3.94)	
ln TRIPTM	--	.6447	--
(t stat.)		(2.85)	
ln AGE	1.662	--	--
(t stat.)	(3.25)		
RES	-1.585	--	-1.824
(t stat.)	(-4.86)		(4.96)
Sample Size	503	241	277
Chi Square**			
Hosmer-Lemeshow	7.773	11.087	7.529
P	.456	.197	.481
Percent Correct Predictions	86.08	86.72	82.31
Sample Means:			
INCOME	42894	48117	--
TRIPTM	--	22.976	--
AGE	42.02	--	--
RES	.649	--	.596

* dependent variable: L=ln(P/(1-P))
** degrees of freedom for Hosmer-Lemeshow is 8

Table 6. Daily Use as a Function of Flow Levels: Big Hole and Bitterroot Rivers.

Variable/Statistic	Estimated Parameters	
	Bitterroot	Big Hole
Intercept	6.04334	6.14211
(t stat.)	(4.04)	(3.63)
DSCHRG	.006584	.020839
(t stat.)	(1.87)	(2.45)
$(DSCHRG)^2$	-3.747E-06	-.00001078
(t stat.)	(2.11)	(1.95)
$(DSCHRG)^3$	4.467E-10	--
(t stat.)	(1.98)	
WKEND	4.6216	3.390690
(t stat.)	(2.83)	(1.73)
DUMSTR	-4.7971	--
(t stat.)	(2.15)	
DUMCOLD	--	-7.278494
(t stat.)		(2.73)
SALDATE	--	5.193589
(t stat.)		(1.80)
R^2	.411	.579
Sample Size	34	37
Variable Means:		
NSAMPLE (dep)	7.50	12.892
DSCHRG	1553.06	507.87
$(DSCHRG)^2$	4,941,342	478,283
$(DSCHRG)^3$	1.9725E10	--
WKEND	.294	.432
DUMSTR	.088	--
DUMCOLD	--	.135
SALDATE	--	.162

Table 7. Welfare Measures of Willingness-to-Pay for Recreational Trip (1988 dollars).

River/Sample	Median	75%	90%	Overall Mean
(A) Estimates				
Bitterroot				
Total Samp.	132	330	820	678
Fish/Float	185	493	1317	1593
Shoreline	78	190	466	362
Big Hole				
Total Samp.	161	389	940	700
Float Angler	214	453	961	548
Bank Angler	143	439	1342	UNDEFINED

(B) Precision*	Median	75%	90%
Bitterroot			
Total Samp.	134.19	341.44	885.34
(S.E.)	(30.61)	(90.05)	(334.01)
C.V.**	.228	.264	.377
Big Hole			
Total Samp.	161.66	391.60	962.95
(S.E.)	(19.93)	(53.57)	(191.50)
C.V.**	.123	.137	.199

*Based on Krinsky and Robb (1986) simulation procedure with 1000 repetitions.
**Coefficient of variation.

Table 8. Marginal Recreational Value as a Function of Instream Flow Levels: Big Hole and Bitterroot Rivers (Dollars per Acre-Foot).

	Bitterroot			Big Hole
DSCHRG	Participation Effect	Quality Effect	Total Marg. Value	Total Marg. Value
(A) Estimated Values				
100	2.88	10.30	13.20	17.65
200	3.32	7.42	10.73	15.80
300	3.90	6.47	10.10	13.58
400	3.27	5.77	9.05	11.58
500	2.99	5.29	8.26	9.61
600	2.70	5.05	7.77	7.35
700	2.27	4.80	7.05	5.54
800	1.66	4.62	6.26	3.33
900	1.13	4.27	5.34	1.36
1000	.47	4.07	4.54	- .60
1200	- .64	3.76	3.16	- 4.82
1400	-1.93	3.43	1.49	- 9.12
1600	-3.09	3.10	.01	-12.61
1800	-4.12	2.61	-1.49	-16.56
2000	-5.18	2.40	-2.75	-21.13

(B) Precision of Estimates*

	Bitterroot Total Marginal Value	Bighole Total Marginal Value
100	13.20	17.65
(S.E.)	(3.27)	(7.47)
500	8.26	9.61
(S.E.)	(2.99)	(3.69)
1000	4.54	-.60
(S.E.)	(2.38)	(3.54)
1500	.75	-10.63
(S.E.)	(1.76)	(8.46)

*Based on simulation with 1000 repetitions using procedure of Krinsky and Robb (1986).

Table 9. Influence of Incomplete Model Specification on Estimated Marginal Recreational Value as a Function of Flow Levels: Bitterroot River (Dollars per Acre/Foot).

Discharge	Participation Effect		Quality Effect	
	Current Study	Value per day Constant	Current Study	Use per day Constant
100	2.67	8.25	12.81	17.51
200	3.14	7.25	9.27	11.72
300	3.23	6.28	7.82	9.26
400	3.11	5.36	6.97	7.84
500	2.85	4.48	6.39	6.89
600	2.50	3.63	5.94	6.20
700	2.07	2.81	5.57	5.66
800	1.58	2.04	5.26	5.24
900	1.06	1.31	4.97	4.90
1000	.52	.61	4.71	4.61
1200	- .62	- .68	4.24	4.14
1400	- 1.78	-1.81	3.80	3.79
1600	- 2.90	-2.79	3.39	3.51
1800	- 3.95	-3.62	3.00	2.28
2000	- 4.90	-4.29	2.64	3.08